

## Claims

What is claimed is:

- 1           1.       Apparatus, comprising:  
2           a die  
3           a heat spreader; and  
4           a thermal intermediate material comprised of a plurality of carbon nanotubes  
5           blended with solder, the thermal intermediate material interposed in a gap  
6           between the die and the heat spreader.
- 1           2.       The apparatus of claim 1, wherein some of the carbon nanotubes of  
2           the plurality of carbon nanotubes are chemically bonded to the solder.
- 1           3.       The apparatus of claim 2, wherein the some of carbon nanotubes of  
2           the plurality of carbon nanotubes are pre-coated with a metal prior to blending  
3           with the solder.
- 1           4.       The apparatus of claim 2, wherein some of the carbon nanotubes are  
2           decorated with metal.
- 1           5.       The apparatus of claim 3, wherein the metal is platinum.
- 1           6.       The apparatus of claim 3 wherein some of the carbon nanotubes are  
2           pre-coated with a metal to wet the solder to bond it to the carbon nanotubes.
- 1           7.       The apparatus of claim 3, wherein the metal is selected from the  
2           group consisting of gold, platinum, silver and palladium and alloys comprising  
3           one or more of gold, platinum, silver and palladium.

1           8.       The apparatus of claim 1, wherein some of the carbon nanotubes are  
2 aligned in the thermal intermediate material along the heat flow path between  
3 the die and the heat spreader.

1           9.       The apparatus of claim 1 wherein the nanotubes are randomly  
2 oriented in the thermal intermediate material and have average lengths less than  
3 about 10 percent of the gap between the die and the heat spreader.

1           10.      The apparatus of claim 1 wherein the solder is indium.

1           11.      A composition, comprising:  
2                   a matrix, wherein the matrix exhibits a phase change between about  
3 100° C and about 230° C.  
4                   a distribution of carbon nanotubes in the matrix having a length  
5 range from about 0.5 micron to about 10 micron, and wherein the interstitial  
6 carbon nanotube heat transfer structures occupy from less than about 5 to about  
7 30 volume percent of the composition.

1           12.      The composition of claim 11, wherein the matrix is a metal selected  
2 from the group consisting of indium or an indium alloy.

1           13.      The composition of claim 12, wherein the carbon nanotubes are  
2 decorated with metal.

1           14.      The composition of claim 13 wherein the metal is selected from the  
2 group consisting of platinum, gold, silver and palladium and their alloys.

1           15.      A method, comprising:  
2                   forming a billet of solder incorporating a plurality of carbon nanotubes  
3 thereon which are chemically bonded to the solder;

4 aligning a substantial percentage of the carbon nanotubes with an axis of the  
5 billet; and  
6 slicing the billet perpendicular to the axis into thermal intermediate blanks  
7 having a thickness substantially less than their length or width.

1 16. The method of claim 15, wherein aligning the nanotubes comprises:  
2 working the billet by a process selected from the group consisting of  
3 rolling, extruding or pultruding.

1 17. The method of claim 15 wherein the thermal intermediate blank is  
2 interposed in a gap between a die and a heat sink.

1 18. The method of claim 15, wherein the gap between the die and the  
2 heat sink is from less than or equal to about 5 microns to about 250 microns.

1 19. A method comprising  
2 forming thermal intermediate structure comprised of a plurality of metal  
3 decorated carbon nanotubes blended with solder with at least some of the  
4 plurality of carbon nanotubes substantially aligned with a thermal axis of the  
5 billet;  
6 coupling a first surface of the thermal intermediate structure to a surface of a  
7 heat sink with the thermal axis of the thermal intermediate material oriented  
8 substantially perpendicular to the surface of the heat sink; and  
9 coupling a second surface of the thermal intermediate structure to a surface  
10 of a heat source.

1 20. The method of claim 19, wherein coupling a surface of the heat  
2 source to the second surface of the thermal intermediate structure comprises  
3 forming a solder bond between the surface of the heat source and the second  
4 surface of the thermal intermediate structure.

1           21.     The method of claim 19, wherein coupling a surface of the heat sink  
2           to the billet comprises forming a solder bond between the surface of the heat  
3           sink and the first surface of the thermal intermediate structure.

1           22.     The method of claim 21, wherein forming a solder bond also  
2           comprises applying a solder wetting coating to the surface of the heat source and  
3           melting the second surface of the thermal intermediate structure to form a bond  
4           with the solder wetting coating.

1           23.     The method of claim 21, wherein forming a solder bond comprises  
2           applying a solder wetting coating to the surface of the heat sink and melting the  
3           first surface of the billet to form a bond with the solder wetting coating.

1           24.     A computing system, comprising:  
2           at least one dynamic random access memory device;  
3           a die including a die surface and a circuit to electrically couple to the  
4           memory device;  
5           a heat sink; and  
6           a thermal intermediate structure interposed between the die surface and the  
7           heat sink and comprising a plurality of carbon nanotubes, some of which are  
8           decorated with metal and blended with solder.

1           25.     The system of claim 24, wherein the circuit comprises a processor  
2           that acts upon data signals, and may include, for example, a microprocessor.

1           26.     The system of claim 24, wherein the metal is one or more metals  
2           selected from the group consisting of platinum, gold and silver and alloys of one  
3           or more of platinum gold and silver.

1            27.     The system of claim 24 wherein the solder is indium.